DEEP INELASTIC SCATTERING AND THE EMC EFFECT

by

Gerald Vincent Dunne , B.Sc.(Ma),Hons.

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Gerald V. Dunne

Contents

Abstract:

This thesis contains a review of theoretical and experimental aspects of deep inelastic scattering. The main predictions of quantum chromodynamics are presented following the introduction of the quark-parton model, operator product expansions and the renormalization group.The recently discovered EMC effect suggests the need for a significant change in the usual QCD treatment of deep inelastic scattering from nuclear targets. The currently popular model involving changes in the quark confinement scale from target to target is discussed, and an inconsistency with the space-time picture of deep inelastic scattering is pointed out. A new explanation, the off-shell model, is proposed and the results for various nuclei are compared with experimental data.

Introduction:

Deep inelastic scattering provides a unique opportunity in the study of the strong interactions because it is both experimentally and theoretically accessible. The agreement between experiment and the predictions of perturbative QCD is quite remarkable. This thesis provides an extensive review of the theoretical predictions of QCD concerning the deep inelastic region. A significant problem with the usual treatment of deep inelastic scattering from nuclear targets has come to light recently. This thesis proposes a new explanation for this problem, the so-called 'EMC effect'.

Chapter 1 contains a review of the basic kinematics of deep inelastic scattering, defining the important kinematic variables, and the 'structure functions'. The second chapter discusses the quark-parton model which was the first serious theoretical treatment of deep inelastic scattering. The main prediction of the quark-parton model is 'Bjorken scaling', a phenomenon observed (approximately) in experiments. The operator product expansion, one of the major mathematical tools in the QCD discussion of deep inelastic scattering, is introduced in chapter 3. Then, in Chapter 4, the field theory quantum chromodynamics is used in conjunction with the operator product expansion and the renormalization group to predict the behaviour of the structure functions as functions of the kinematic variables. Chapter 5 contains a discussion of the recently discovered (1983) EMC effect. The essence of the EMC discovery is that deep inelastic scattering of leptons from nucleons has a significant dependence on the target nucleus. An inconsistency in the currently most popular 'explanation' of the EMC effect is pointed out in this chapter. In the

final chapter, a new parameter-free model is proposed which consistently incorporates target dependence into the QCD theory of deep inelastic scattering. This involves accounting for the 'off-shell-ness' of the nucleons in a given nucleus due to nuclear binding effects. This necessitates a modification of the usual Fermi averaging procedures and also introduces a 'Q^2 - rescaling' effect. The new method is applied to many different target nuclei, and good agreement with experimental data is obtained.